



## Using collaborative hackathons to coproduce knowledge on local climate adaptation governance



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### ABSTRACT

While coproduction of knowledge is growing in popularity in social sciences, and especially climate change research, we still need to better understand *how* to coproduce climate knowledge. In this paper, we explore how collaborative climate hackathons coproduce local adaptation knowledge, and what this method reveals about local climate governance. The data derives from two collaborative climate hackathons, called Klimathons, that attracted 73 and 98 participants in Bergen, Norway. The participants were practitioners and decision-makers from local, regional, and national institutions as well as researchers from natural and social climate sciences. The collaborative group work revolved around the challenges and solutions of local adaptation planning and uncovered how a diversity of key actors understand the local adaptation work in Norway. These interventions revealed that there are significant disagreements and divergent understanding of relevant laws, regulations and responsibility between practitioners working within the same governance system. Though the cross-sectorial interaction does not dissolve these divergences, they allow actors to renegotiate boundaries between divergent knowledge communities. The Klimathons helped us navigate the complexity of local climate adaptation by shifting the focus to how different actors make sense of and work on adaptation and showing the intertwining and interdependence of potential drivers for adaptation.

### 1. Introduction

Knowledge of the challenges, needs, and opportunities for climate adaptation has advanced significantly in recent years (Di Giulio et al., 2019; Dilling et al., 2017; Ekstrom and Moser, 2014; O'Brien, 2017; Reckien et al., 2015). Research has for example elucidated the likely contributing factors to adaptive capacity and communities' potential for adaptation (Berrang-Ford et al., 2014). However, adaptation is neither inevitable nor automatic, even where adaptive capacity is presumably high, as in Norway (Berrang-Ford et al., 2014; Burch, 2010; O'Brien et al., 2004), and there is little empirical evidence on the process of stakeholder involvement and coproduction in the development of municipal adaptation strategies (Wamsler, 2017).

Previously, much research on climate adaptation governance has revolved around how existing systems can be instrumentally fine-tuned and adjusted, rather than understanding how the interplay between the organization of knowledge and the development of support for such organization within governance can be nurtured (Termeer et al., 2013). Accordingly, we need to explore empirically how municipalities and related actors navigate the politics of adaptation and formulate responses to climate risk (Dilling et al., 2017). This decision-making space is filled with voices from many

sectors and disciplines, providing an opportunity to test new forms of dialogue. Thus, climate change adaptation requires collaborative and coproductive efforts. For our purposes, collaborative climate hackathons can improve climate governance by providing a new mode of knowledge coproduction in climate adaptation, and allowing the development of new perspectives from actors that traditionally do not work together (Trainer et al., 2016).

In this paper, we ask, firstly, how collaborative climate hackathons coproduce local adaptation knowledge, and secondly, what this coproduction method reveals about local climate governance. Based on a semi-structured hackathon method employed in a Norwegian context, the results offer insights into how practitioners and decision-makers make sense of the challenges and solutions in local climate adaptation planning. The qualitative data analyzed in this paper comes from two knowledge coproduction events framed as collaborative climate hackathons, organized to foster deliberate cross-sectoral and interdisciplinary collaboration and create insights into challenges for local climate adaptation governance.

The paper proceeds as follows. Section 2 reviews literature on how coproduction and collaborative climate hackathons are helpful for exploring local climate adaptation governance in the Norwegian context. Section 3 outlines the methods of our collaborative climate hackathon process.

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Section 4 describes the findings from the Klimathons, and section 5 discusses and concludes what the climate hackathons reveal about local climate adaptation governance.

## 2. Understanding coproduction and governance of local climate adaptation

### 2.1. Coproduction of local adaptation knowledge – Collaborative climate hackathons

A wide range of factors and conditions shape climate adaptation and governance at the local level. Arguably, researchers can engage with this complexity and contribute to adaptive agency through coproduction of knowledge (Berkes, 2009; Lemos and Morehouse, 2005; Wall et al., 2017). Coproduction acknowledges how data and scientific knowledge is created through the interactions between the many different actors involved in a research process (Bremer and Meisch, 2017; Jasanoff, 2010). Instead of creating theoretical models of the relationships between abstract factors, coproduction focuses on practitioners' experiences and interpretations of challenges. Coproduction has been particularly relevant where the division between science and policy is blurred, increasing the need for interaction between scientists, policymakers, and the public (Lemos and Morehouse, 2005).

In this context, coproduction can be understood as a deliberate collaboration between actors to achieve a common goal (Lemos, 2015; Lemos and Morehouse, 2005; Ostrom, 1996). This resonates well with the intentions and ideas behind the collaborative climate hackathons in this study, bringing together actors with differing perspectives, values, and foci.

The word hackathon consists of the two words *hacking* and *marathon*, and has traditionally been associated with coding and software development (Briscoe and Mulligan, 2015). Hackathons have also been used to address a variety of societal issues, including urban development, health education, and homelessness (Aungst et al., 2019; Baccarne et al., 2014; Linnell et al., 2014; Pogačar and Žižek, 2016). While classic hackathons emphasize technical “hacking” approaches, they have also facilitated community-based learning and interdisciplinary or intersectoral collaboration (Duncombe et al., 2018; Lara and Lockwood, 2016). Therefore, this form of knowledge coproduction can provide an “institutional trigger” (Armitage et al., 2011) that allows learning across disciplinary or institutional boundaries, builds trust, and strengthens relationships between actors over time (Bremer and Meisch, 2017).

In a hackathon, participants from different fields, competencies and specialties gather to work collaboratively, often over 24 to 48 hours, to develop new solutions to a pre-defined problem. Both creativity and autonomy in the problem-solving process are crucial elements of the hackathon method (Pogačar and Žižek, 2016). Traditional hackathons have often been arranged as competitions where the participants can win prizes or funding for their ideas, and achieve prestige and contact networks (Pogačar and Žižek, 2016). Arranging a hackathon for the scientific purpose of gathering data needs adjusting and systematic preparations. How we did this, is outlined in detail in section 3.

### 2.2. Factors influencing local adaptation governance

To understand the outcomes from the Klimathons, it is useful to review what research already tells us about what enables or hinders local climate adaptation governance.

Climate adaptation governance refers to the ways in which public, private, and civil society actors and institutions articulate goals, exercise influence and authority, and manage planning and implementation processes. While successful mitigation and adaptation require measures taken by international and national actors, many initiatives and solutions are designed and implemented at the local level (Anguelovski and Carmin, 2011). Over the past decade, research has identified a diverse range of barriers and drivers of local climate adaptation (Biesbroek et al., 2015; Eisenack et al., 2014; Moser and Ekstrom, 2010). Ample research highlights how a range

of organizational, technical, resource, or institutional conditions affect adaptation governance (Lawrence et al., 2015; Reckien et al., 2015; Simonet and Leseur, 2019).

The two first Klimathons focused on finding solutions to local adaptation challenges. In this study we develop an analytical framework to understand the value of collaborative hackathons in developing knowledge of local adaptation governance. Based on current climate adaptation literature, we will discuss how knowledge, political leadership, and institutional factors affect and potentially drive local adaptation and governance processes.

First, *the role of knowledge* is important in existing adaptation literature. Scientific climate knowledge is emphasized as key to understanding the potential impacts of climate change and developing adaptive strategies (Adger, 2007). Even though the growing body of scientific knowledge does not itself lead to growing consistency in societal attention, political commitment, or state interventions (Vink et al., 2013), knowledge connects climate adaptation and local political agendas, influencing priorities and anchoring decisions. For example is reducing the impact of a natural hazard contingent on recognizing knowledge gaps in adaptation processes, and coproduction has increasingly been perceived as a way to increase local adaptive capacity (Dannevig et al., 2013).

In this context, a range of research institutions, companies, and local authorities have contributed to the production of climate services, which are relevant forms of knowledge to inform decisions and policymakers on local adaptation needs (Hewitt et al., 2017). Effective engagement between actors who use, produce and even coproduce new knowledge is seen as an essential element of any climate service (Hewitt et al., 2017; Kolstad et al., 2019). Thus, interactions between governance actors could even drive effective climate governance, provided that climate information meets practical needs and that new knowledge is integrated into existing knowledge and decision contexts (Lemos, 2015). In such settings, coproduction may create forceful epistemic communities or networks that have increased capacity for climate action.

Second, *the role of political leadership* is frequently identified as necessary to implement adaptation successfully (Anguelovski et al., 2014; Dilling et al., 2017). Leadership can be critical at different stages of an adaptation process, but perhaps most important in initiating the process and sustaining momentum over time. Such formal as well as informal leadership relates to the ability to identify and agree on adaptation goals along with ways to achieve them (Moser and Ekstrom, 2010). Leadership can come from any position in the governance hierarchy, but top-level leadership from a supervisor, mayor or other elected official is commonly seen as critical to get adaptation on the political agenda. Further, where there is political leadership, funding follows (Moser et al., 2019).

In a local governance context, political leadership includes the distribution of ownership and support for administrative processes. In practice, political leadership is exercised by local stakeholders initiating and supporting changes in legislation, policy documents, and has been identified as a key resource for urban climate change adaptation (Ekstrom and Moser, 2014; Uittenbroek et al., 2013). As such, a combination of leadership, local government support, and stakeholder buy-in has been proven necessary to implement adaptation measures (Anguelovski et al., 2014; Dilling et al., 2017).

Third, *institutional* factors are recognized as important elements in enabling, constraining, and shaping climate adaptation (Birkmann et al., 2014; Patterson et al., 2019). These relate to factors such as organizational development, regulatory environments, access to technological innovation, public awareness and opportunity for outreach, capacity for monitoring, and financial support. Given the breadth and complexity of institutional factors, research remains inconclusive about which are important and their influence on adaptation, decision-making, and performance (Oberlack, 2017). According to Berrang-Ford et al. (2014), institutional capacity is the strongest predictor of national adaptation policies and action. At the local level, this is apparent in institutions' capacity for internal and external communication, cohesion, and motivation (Dannevig et al., 2013). Local areas are where abstract policy goals “hit the ground”, and where conflicts and contradictions must be resolved. Of course, this does not mean that all solutions are distinctly local – “local” climate governance is involved in many cross-scalar

interactions (Haarstad, 2014). However, it remains crucial to integrate the effects of institutional factors to understand solutions of local adaptation work. Effective governance is a cross-sectoral and multilevel endeavor and coordination between actors and institutions remains a key challenge (Cashmore and Wejs, 2014; Lodge and Wegrich, 2014).

### 2.3. Local adaptation and governance in the Norwegian context

It is useful to give an overview of climate adaptation in the Norwegian context since both Klimathons took place in Norway. Norwegian municipalities vary greatly in their geographical features, organizational resources, and societal needs. According to Westskog et al. (2017), Norwegian national and sectoral governmental authorities and policies do not sufficiently recognize these significant variations.

During the last decade, local adaptation work in Norway has developed from a situation characterized by municipal confusion about how to adapt to climate change, to gradually improving local adaptation knowledge (Orderud and Naustdalslid, 2020). A common explanation for confusion and failure to implement effective climate adaptation in Norway is the lack of coordination between municipal departments and with regional and national stakeholders (Amundsen et al., 2010; Neby, 2019; Westskog et al., 2017).

In Norway, the national authorities are responsible for facilitating and overseeing compliance with national requirements, guidelines, and intentions by municipalities. The Planning and Building Act requires Norwegian municipalities to be formally responsible for planning and implementing measures that safeguard the municipality and the residents, including handling the impacts of climate change (Westskog et al., 2017). The municipalities are also required by the Civil Protection Act to develop overall risk and vulnerability analysis's (RVAs) that incorporate climate change and to prepare and develop adequate measures for responding to potential climate events (Westskog et al., 2017).

Although, the national level in Norway controls and guides the municipalities' work on climate change, the municipalities have a significant degree of freedom when designing their policies, including climate adaptation policies (Westskog et al., 2017). Research has shown that Norwegian municipalities also implement adaptation policies that are not initiated at the national level, and this often depends on the efforts of individuals within the municipal organization, municipal size, and the use of external expertise (Dannevig et al., 2012).

## 3. Methods: Coproducing actionable climate knowledge

### 3.1. Hybrid climate hackathons

The two collaborative climate hackathons were held in Bergen, Norway, and engaged Norwegian practitioners and researchers. The first Klimathon in 2018 (K1) came from the experiences of a set of multidisciplinary projects that entailed collaborations between research communities and practitioners in municipalities, counties, and government agencies over years. As we recount elsewhere (Kolstad et al., 2019), we discovered early in the working process that cross-sectoral collaboration is more challenging than is often assumed. K1 was devised to improve the collaboration and knowledge exchange between institutions, practitioners, and governance levels, which we had observed to be lacking in previous project work. An overarching motivation behind organizing the climate hackathons was precisely to overcome the barriers of a lack of cooperation and coordination between governing actors, administrative levels, and scientific communities.

The second Klimathon in 2019 (K2) built on this initial effort to develop a more engaging collaborative process, drawing more explicitly on actors' problem-solving skills. Both Klimathons were facilitated by a systematic process methodology informed by the problem-oriented and collaborative ethos of traditional hackathons.

We aimed for a broad representation of participants – geographical, disciplinary, and sectoral – for the discussions during the climate hackathon events. Because the main research theme was adaptation in municipal

planning, the main target group was municipal planners. An important aspect of the Klimathons was to allow for the methodology to incorporate a representation of a realistic context. The representation of the most relevant actors working within the Norwegian adaptation field in each group, framed the hackathons as a qualitative experiment in a realistic – but not real – setting. Actor, sector, and knowledge representation substituted the formal roles of decision-making processes, and the participants were encouraged to draw on their real-life experiences.

Creativity and autonomy in the problem-solving process are crucial elements of the hackathon method (Pogačar and Žižek, 2016). Therefore, at K1, we asked the participants to discuss openly and present a decision-making process for municipal climate adaptation work where they met all the current challenges in that process. For our purposes, the hackathon method was adjusted to achieve certain research objectives; for example, there was no focus on competition (Briscoe and Mulligan, 2015), but rather on cooperation, learning, information sharing, and communication within and across the working groups. To achieve a broad range of experiences, the organizers composed the groups and assignments strategically, which challenged the autonomy elements of the original hackathon format. The discussion process for K2 was also deliberately structured to accommodate efficiency and focus, an approach not common in classic hackathons.

Even though coproduction approaches are intended to democratize knowledge creation processes through better inclusion of nonscientific actors (Funtowicz and Ravetz, 1993), potential ethical problems are still involved, for example, asymmetrical relationships and the power to define the questions. We tried to negate this by being as transparent as possible in the organization process (e.g., by involving practitioners in the planning committee), and inviting comments on the final reports before publication.

### 3.2. Structuring the hackathon work process

At the Klimathon events, 12 (2018) and 10 (2019) interdisciplinary and intersectoral groups collaborated intensively over two days, discussing and designing practical and strategic solutions to the challenges of planning and implementing climate adaptation at the local level (See Table 1 for an overview of participant backgrounds and Fig. 1 for photos from the events). The wide variety of backgrounds of group participants reflected a complex reality in the decision-making processes of municipal planning and climate change adaptation. This allowed the participants to exchange experiences and discuss the different perspectives. The collaborative hackathon events provided a specific arena for understanding others' daily realities through collaboration and dialogue across research environments, practices of policymaking, and levels of public administration.

When preparing for K1, we challenged the groups to work toward improved decision-making processes and present a theoretical decision-making process for local climate adaptation planning. The tasks at K1 required the participants to design solutions to improve the decision-making processes around climate adaptation and to facilitate climate adaptation work for planners, especially in smaller municipalities. The motivation behind this was to provide actionable scientific climate knowledge for decision-making that would make Norwegian municipalities and communities better equipped and competent to manage future climate change. This format proved to be challenging, and most of the groups focused mainly on the formulation of challenges and solutions

**Table 1**  
Participants in Klimathons 2018 and 2019.

Participant background	K1 2018	K2 2019
Municipalities in Hordaland	11	14
Municipalities outside Hordaland	14	16
Regional County Council/Regional Governor	18	15
University/Research Organization	18	30
National Government Agency	6	12
Planning Consultancy	2	8
Private Sector	4	3
<b>Total</b>	<b>73</b>	<b>98</b>



Fig. 1. Klimathon I and II. Photos from the Klimathon group work and presentations.

in the planning processes and less on presenting a theoretical decision-making process. All the groups presented their solutions in a plenary session on the second day of the event.

The methodology and tasks of K1 were revised and improved for K2. An expressed goal for K2 was for the participants to align perspectives across the different participant types and to develop shared perspectives among the participants. From discussing one common task about adaptation in area planning at K1, we developed four distinct tasks for K2. The themes of the four tasks were (1) water-related issues; (2) nature, agriculture, and cultural heritage; (3) organizational and institutional processes; and (4) climate vulnerability and emergency preparedness. The tasks asked the participants to develop innovations, such as new policies, governance solutions, or products that would draw on the expertise of the group, and to agree on a short-term plan for their respective institutions to progress the idea.

At K1, the group discussions were not formally structured. The only means of keeping the discussions on track was an assigned (but informal) group leader in each group. At K2, the group discussions were structured pedagogically as pyramid discussions, a dialogue method to give all participants time to speak while pushing the discussions forward (Hampel and Heckmann, 2005; Jordan, 1990).

At K2, the participants were asked to create a mind-map showing the range of knowledge, processes, and actors that were pertinent to their

case. This allowed participants to ground their assigned task in their own contexts and experiences. The mind-map allowed them to connect different elements and helped them to identify recurrent issues. Each group then had to identify one or two leverage points for change, that is, elements that occupied a crucial position on their map and required the participants to agree on a limited set of issues to be prioritized. Continuing, the groups were required to develop innovations, such as new policies, governance solutions, or products, that would draw on the expertise of the group and address identified issues. Finally, the participants had to agree on a short-term plan to carry the idea through in their respective institutions. Deliberation and discussions are at the core of this process, and as organizers, we expended considerable effort on streamlining the process. All the groups presented their solutions in a plenary poster session the second day of the event, where also local politicians were invited.

### 3.3. Analyzing data from the two climate hackathons

The two Klimathon events coproduced a rich data set. From K1, we coproduced 12 digital group presentations on solutions to local adaptation challenges, individual notes of reflection about the working process from all 12 group leaders, and evaluations from the K1 participants. From K2, we coproduced 10 group posters with mind-maps of their adaptation

strategies (See Fig. 2 for examples), reflective notes from 10 group leaders, evaluations from the participants, and designated field notes from one social science researcher.

Analyzing the qualitative data from K1, we systematically summarized the group discussions in an extensive table containing three categories related to the decision-making process for adaptation: 1) challenges,

### KLIMATHON II HELHETLIG STYRING, ORGANISERING OG LEDELSE

**Tittel**  
PARTNERSKAP FOR KLIMATILPASSING

**Problem/UTFØRDRING**  
KORLEIS JOBBE FORPLIKTANDE OG SYSTEMATISK MED KLIMATILPASSING?

**Løsning**  
ANSVARLEGGJERING!

**Veien videre**

- KORTLEGGING EKISTERANDE NETTVERK - INNE DEI AKTIV
- BEIEN FOR KLIMATILPASSINGSREKVISITT? SOR ER INNE TILSTREKKELEG
- SJA PÅ ANDRE MEDLEDER SOM INKLUDERER UTLEVERINGAR SOM
- NYTTE NOKADAPT AKTIV FOR Å MERE KUNNSKAPEN I NERKREIET
- KLIMATILPASSINGANE SOM FAST PUNKT PÅ REGJERINGEN I NOTER

### KLIMATHON II VANN OG MERE VANN

**Tittel**  
VANN PÅ TVERS: Problem, kompetanse, løysingar

**Problem**  
MANGE ULIKE FAG/TEMA: ØKONOMI, MANGE BUDSJETT

**Løsning**  
MEIR PENGER, FORMIDLING AV RISIKO, KOMPETANSE

**Veien videre**  
(INTER) KOMMUNE - Avrenningsløyper, KLIMASKATT, KLIMA-KUNNSKAP (SE HAVNIVA FA), APP HAVNIVA PÅ HOBB-BILDE

### KLIMATHON II NATUR, LANDBRUK OG KULTURMINNER

**Tittel**  
FUNKSJON & VERDSETJING AV ØKOSYSTEM

**Problem**  
KORLEIS INKLUDERA VERDIEN AV ØKOSYSTEM/ AREALBRUK I FORVALTINGA PÅ EIN GOD MÅTE?

**Løsning**

**Veien videre**  
INTERKOMMUNALT NETTVERK FØREBYGGINGSFOND, UNNGÅ DISPENSASJONER, ØKE LOKALT ENGAGEMENT

### KLIMATHON II SAMFUNNSSIKKERHET I ET ENDRET KLIMA

**Tittel**  
SAMHANDLING FOR KLIMAHANDLING

**Problem**  
STYRKE PRIORITERING, KAPASITET, KOMPETANSE, OG SAMHANDLING I KOMMUNANE FOR Å AVDEKKE OG VURDERE KORLEIS LOKALE FORHOLD OG KLIMAEFFENSERER KAN PÅVERKE LOKAL SAMFUNNSSIKKERHET

**Løsning**  
KVA: NATURFAREANALYSE, KVEN: NATURFARERÅDGJEVAR, KORLEIS: SAMHANDLING

**Veien videre**  
SAMSPILL, OPERASJONSLØSNING, ISÅ & TIL 50 ÅR

Fig. 2. Klimathon II posters. A selection of posters from K2 showing the group presentation solutions. Titles: “Climate adaptation partnerships,” “Water crossing borders,” “Valuing ecosystem services,” and “Climate action collaboration.”

2) solutions, and 3) the way forward. Producing this table of categories required a systematic analysis of the themes and solutions presented. After getting an overview of the data, we placed the different themes from the presentations into the three categories. We then counted how many times the groups presented each of the identified themes to get an impression of which themes were most important to the groups. Importantly, though some thematic challenges were discussed more than others (like knowledge or political will), the solutions were intertwined and often came from other themes (like resources for competence building or cross-sectoral collaboration).

Analyzing the data from K2, we held a dedicated workshop to examine the 10 posters, drawing important connections between themes, challenges, solutions, and drivers of adaptation from each group. This material was supplemented by detailed field notes from the group discussions from one social researcher with the role of an observer at the event. For both K1 and K2, we made written reports that summarized and synthesized the workshop, assignments, methods, and results from the workshops. This collective process of analyzing the data in practice consisted of three steps. First, as a preparation, all involved researchers had the chance to familiarize themselves with the existing material. Second, we collectively assessed each main item of the data – particularly the poster presentations – while opening for deliberation on interpretations and taking notes. Third, we grouped the data based on thematic distinctions and made a loose, collectively agreed prioritization to signal what themes were considered more important than others. This approach resembles the method ‘collective qualitative analysis’ as described by Eggebø (2019), but differs in the sense that our data were already “filtered” and semi-processed through the coproduction processes of K2.

These reports are openly available (in Norwegian) and serve as a documentation of both the Klimathon process and the rudimentary findings (Kvamsås and Stiller-Reeve, 2018; Neby, 2020). Together, this material provided extensive reflections on how the participants, with all their varied professional experience of climate work, perceive solutions to local adaptation challenges.

Finally, it is important to note that – as any qualitative work – the processing of the material gathered from the Klimathons relied on an interpretative approach. We emphasized to identify themes that were reflected across groups. In practice, this involves a process of condensation and abstraction by us as researchers. This interpretation was also a process of deliberation between the authors of this paper. This condensation, abstraction and deliberation thus builds on the analytical and methodological competencies of each participating researcher, but it is important to note that deliberation also entails assessing claims, interpretations with a critical perspective as much simply reviewing the data. The group of researchers represent interdisciplinary approaches to climate change adaptation, spanning both social and natural sciences. Interdisciplinarity is a characteristic of adaptation challenges, which we thus attempted to “match” by working across academic specialties.

## 4. Findings

This section presents findings and reflections concerning how the Klimathon participants made sense of the practical work of climate adaptation, focusing on the roles of knowledge, political leadership, and institutions.

### 4.1. Understanding solutions to climate knowledge challenges in municipal planning

At K1, the most discussed topics concerned the quality and quantity of climate knowledge and the need for competencies to facilitate local climate adaptation. A lack of general climate knowledge among the governance actors and gaps in the scientific climate knowledge were identified as challenges. It was acknowledged that although the actors that contribute to local adaptation governance may have such knowledge, it is often not accessible or systematized in a manner relevant to local planners or

decision-makers. Although the discussions reflected subjective experiences of lacking knowledge and relevant climate data, not all actors reported similar needs. Indeed, many of the researchers found this somewhat surprising, as they expressed satisfaction with their access to several sources of systematized information. This may indicate that some actors do not know where to find relevant information or how to process it, rather than an actual absence of knowledge and data. Crucially, mapping local information and knowledge needs and conditions was also underlined by practitioners as a way to develop more contextual and relevant knowledge support.

A majority of the groups at K1 promoted professional training and formal certification in the municipalities as solutions to these challenges. They focused on the importance of securing professional training for both administrators and politicians, for example, to increase legal competence in the municipalities and build local competence. Specifically, they suggested more guidance and advice from researchers, as well as from regional and national authorities such as the county council, the county governor, or the National Environmental Agency. Some held that improved visualization of data and contextual knowledge of climate effects would facilitate the local absorption of knowledge. One specific suggestion was that municipalities could “borrow a visiting researcher” to aid the integration of climate knowledge into their governance processes (this was tested by a municipality in northern Norway the following year).

At K2, the need for further knowledge and competences in climate adaptation work also emerged as a key topic. However, this time, we saw examples of how participants developed proposals to facilitate knowledge exchange. After two days of discussions, an emerging emphasis seemed to be the awareness that knowledge is created in a particular context, rather than simply transferred from its possessors, like the researchers or state agencies. They suggested new arenas, platforms, and methods for gathering and presenting data. In addition, they tended to link knowledge generation to political decision-making processes by suggesting mechanisms for embedding political decisions in contextualized knowledge and making specific political actors responsible for local climate adaptation work.

For instance, one group at K2 proposed changes to the local–regional governance structure to improve the commitment and systematization of local climate decision-making. The members suggested establishing a “Regional Climate Forum” involving administrators and politicians – including opposition politicians. The forum would institutionalize responsibility for climate action, and it was planned how this would fit within the existing system of governance. It was emphasized that this solution relied on existing active and engaged networks because several informal networks with similar purposes have already been established. Interestingly, the participants at K2 – drawing on challenges from their regular work – were more interested in integrating and institutionalizing knowledge creation and deliberation.

### 4.2. Understanding the need for political support and clarification of responsibility

At K1, the second most discussed topic was the frequent lack of (and need for) political support to prioritize climate adaptation in local planning. This was repeatedly attributable to politicians’ lack of knowledge and will to act. Although municipal planners are often at a considerable distance from the political agenda, some had found that climate-related events like floods, stormwater events, or landslides had highlighted climate adaptation. At K2, the discussions on political support reflected a need to promote political ownership and institutionalize climate adaptation in municipal planning. One group even suggested that municipal climate adaptation work needed a new type of organization that should be more task oriented. The participants requested broad political anchoring in municipalities and counties, including anchoring of climate adaptation in overarching municipal and regional plans. Several groups at K2 promoted dialogue-oriented planning processes to address such challenges and called for the inclusion of politicians at early stages of the planning processes.

Responsibility and accountability were also widely discussed in connection to the role of politicians at both Klimathons. At K1, the municipal

practitioners talked about the fragmentation of accountability, stating that although all the actors had a common responsibility for climate adaptation, none was generally accountable. Specifically, different groups asked for authorities to clarify responsibilities for issues such as sea level rise and stormwater management. To resolve this, they asked for clarification of the overarching responsibility for climate adaptation at the national level, and for actors at all levels to be assigned a specific role. Preparing a comprehensive overview of the existing roles and responsibilities at the national level was also seen as a step toward a structure of accountability.

Regarding local climate adaptation processes, these results suggest extensive uncertainty and confusion concerning the lack of responsibility. However, a nuanced interpretation of the demand for political anchoring, will and support and clear responsibility suggests that municipal planners desire political support more than actual involvement in climate adaptation. At K1, several suggestions concerned politicians' support in the planning process, whereas at K2, politicians were directly mentioned as important actors in the proposal for formal climate networks. In continuation, one may also interpret this situation as symptomatic of the sectoral boundaries that cut across both the internal organization of the municipalities, and across the actors that municipalities engage with in climate adaptation governance. Political involvement could thus be a strategy for legitimizing adaptation processes, but such legitimizing comes with a potential downside for experts and bureaucrats: it opens the door for political engagement to interfere with professional discretion.

#### 4.3. Understanding the need for cross-sectoral collaboration between and within institutions

From the start, the collaborative hackathon method aimed to overcome fragmentation and knowledge silos in climate governance. At K1, the coordination challenges were raised in the majority of the group discussions. The groups often reported a lack of interdisciplinary and cross-sectoral collaboration, as well as a lack of holistic thinking in local governance. In addition, some participants indicated that divergent understandings of the important issues were a considerable challenge.

Engagement with research environments was generally presented as important to local adaptation work. The groups also called for more contact with the private finance sector and the need for "knowledge brokers" between sectors and disciplines. At both Klimathons, several participants perceived the Klimathon to be an arena for interdisciplinary collaboration between the public administration and the research environments. Some groups suggested establishing new networks and strengthening existing ones. Importantly, the collaboration platforms discussed aimed to promote the participation of a variety of actors in terms of ownership and identity in the climate work. However, these suggestions lack specificity concerning the effects and practicalities of networked or collaborative arrangements.

At K2, one group considered managing water matters more holistically by including them directly in the municipality's mainstream planning processes. The solutions concerned developing more flexible municipal plans with better adaptation to local climate effects. They suggested the creation of a specific governance authority, such as a "Water Office", that would gather competencies, skills, and knowledge and have clear authority over water matters.

A recurring topic at both Klimathons was the need to gather and share examples and best practices from municipalities and actors that had progressed furthest with practical climate adaptation measures. One group at K2, working on the theme of nature, agriculture, and cultural heritage, suggested developing a platform to document these best practices and propose solutions to common problems. The proposed platform was seen both as a possible inspirational database of solutions and a basis for further data collection and development of new pilot projects.

The theme of laws and regulations was discussed substantially as a solution more than a challenge. The main arguments concerning laws and regulations at K1 showcase the need for binding guidelines and consistent interpretation and implementation of regulations across municipalities.

At K2, one group specifically proposed stricter requirements for climate adaptation in existing laws and regulations.

## 5. Discussion and conclusion: Lessons from the Klimathons

At the onset of this paper, we asked how collaborative climate hackathons coproduce local adaptation knowledge, and what this coproduction method reveals about local climate governance. In section 3, we presented the methodological choices of our collaborative climate hackathons in detail. In section 4, we discussed the empirical patterns that we drew from the climate hackathons. Here, we highlight the more general analytical findings from the Klimathons.

The coproduction of knowledge in collaborative hackathons can be useful for understanding local climate adaptation in ways that recognize the complexity of factors affecting governance processes. We can use the results from hackathon-type events to gauge the perspective of municipal practitioners and tease out insights from their engagement in collective problem solving. The Klimathons helped us navigate the complexity of local climate adaptation (Bremer and Meisch, 2017; Dilling et al., 2017) by shifting the focus to how different actors make sense of and work on adaptation and showing the intertwining and interdependence of potential drivers for adaptation. As for what the collaborative climate hackathon method reveals about local climate governance, there are several engaging lessons.

The first lesson concerns the importance of increasing the competence of local planners and decision-makers in using available knowledge, allowing knowledge to become an empowerment for actors in climate governance. The Klimathon participants called for more knowledge brokers, more local scale climate data, more practical examples of best practices, and more coproduction of knowledge with researchers. Simultaneously, the discussions on political and institutional factors noted the slow and conflicted processes of receiving and acting upon knowledge, as well as the importance of contextualizing knowledge (making generalized knowledge applicable to the specificities of localities).

While the lack of knowledge is typically cited as a key barrier to adaptation (Ekstrom and Moser, 2014), our material suggests that too much knowledge can be an equal hindrance. It seems that creating additional knowledge brokers has clear costs and creates new institutional pathways to be navigated. Nevertheless, improved competence in knowledge generation and application could facilitate local adaptation governance because it lays an important foundation for political and administrative engagement and skills, sets targets, and applies the working strategies and measures to achieve them.

These reflections illustrate how the cross-sectoral groups at Klimathon discussed and understood the causal processes to pursue climate adaptation goals and actions (Biesbroek et al., 2015). Developing climate knowledge and building competence is influenced by political will, leadership and funding (Moser et al., 2019), and the Klimathon dialogues show concretely how intertwined and interdependent these processes can be.

Second, the practitioners at the Klimathons called for political leadership, although not necessarily political involvement per se. The groups concretely lamented the lack of climate engagement of most politicians and the related lack of resources. While political leadership is frequently identified as a core driver of adaptive governance, adaptive capacity and funding (Dilling et al., 2017; Moser et al., 2019), the Klimathon dialogues reveal how the participants equal political leadership with political support, and how this political support is necessary for generating resources for adaptation measures.

A related finding, supporting existing literature (Dannevig et al., 2013), agenda-setting weather events seem to increase political support followed by resources, but not necessarily other forms of political involvement, like deeper political ownership or engagement in administrative processes (Ekstrom and Moser, 2014). In this context, unlocking effective climate adaptation requires municipalities to have strong institutional capacity, including public officials equipped to implement prioritized measures when disaster strikes. This underscores the complex and often unpredictable interactions between adaptation drivers.

Importantly, Klimathon participants signaled that they need room to maneuver to implement solutions based on existing knowledge. Several groups emphasized the difficulty of balancing the holistic management of climate adaptation while setting priorities within the given economic, knowledge, and political constraints. In addition, they called for greater capacity to regulate and clarify roles and responsibilities. Such clarification may inform climate governance because it defines the people responsible for jobs and for paying the costs.

The Klimathon dialogues thus reveal the participants' collective understanding, making it possible to nuance and understand previously identified adaptation knowledge. The interventions also reveal that there are significant disagreements and divergent understanding of relevant laws, regulations and responsibility between practitioners working within the same governance system.

Finally, our findings suggest that, if systematized, collaborative coproduction of knowledge might help local adaptation governance, which in Norway is still characterized by notable confusion about how to adapt to climate change (Orderud and Naustdalslid, 2020). It was evident that it was unclear to many practitioners in the field exactly who was responsible for various governance tasks, even in a well-governed context such as in Norway. Resolving this divergence is important, given the gap between the perceived need for climate information and its use (Lemos, 2015). A common explanation for confusion and failure to implement effective climate adaptation in Norway is the lack of coordination between municipal departments and with regional and national stakeholders (Amundsen et al., 2010; Neby, 2019; Westskog et al., 2017). Collaborative trials like the Klimathon events can help overcome what is often seen as an overarching barrier to adaptation—that is, insufficiently coordinated and ineffective governance processes that hamper the exchange of knowledge and sharing of responsibility (Cashmore and Wejs, 2014).

Although the interactions at the Klimathons did not resolve all disagreements and divergent understandings, they allowed participants to renegotiate boundaries between actors and communities, knowledge systems, and challenges, and they prompted participants to expand and adjust their perspectives on climate adaptation. Because the implementation of climate adaptation measures and governance processes are dynamic and messy political processes that include many actors and voices, the coproduction of knowledge in the form of collaborative hackathons may help legitimize the shared proposals.

The interest and engagement by the participants in the two collaborative climate hackathons suggest that practitioners gain in competence and were empowered to become further involved. Thus, collaborative climate hackathons can promote collaborative professional learning processes, which might help practitioners make sense of the complexities they face in everyday governance.

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## References

- Adger, N., 2007. Climate Change 2007. Climate Change Impacts, Adaptation and Vulnerability. Summary for Policymakers. Intergovernmental Panel On Climate Change Fourth Assessment Report. Geneva, IPCC.
- Amundsen, H., Berglund, F., Westskog, H., 2010. Overcoming barriers to climate change adaptation—a question of multilevel governance? *Environment and Planning C: Government and Policy* 28, 276–289.
- Anguelovski, I., Carmin, J., 2011. Something borrowed, everything new: innovation and institutionalization in urban climate governance. *Curr. Opin. Environ. Sustain.* 3, 169–175.
- Anguelovski, I., Chu, E., Carmin, J., 2014. Variations in approaches to urban climate adaptation: Experiences and experimentation from the global South. *Glob. Environ. Chang.* 27, 156–167.
- Armitage, D., Berkes, F., Dale, A., Kocho-Schellenberg, E., Patton, E., 2011. Co-management and the co-production of knowledge: Learning to adapt in Canada's Arctic. *Glob. Environ. Chang.* 21, 995–1004.
- Aungst, T.D., Patel, R., Pugliese, R., Patel, I., Boutari, C., 2019. From ideation to practice: how pharmacists and students can leverage hackathons and innovation labs to accelerate innovation in pharmacy. *Journal of the American Pharmacists Association* 59, S25–S29.
- Baccarne, B., Mechant, P., Schuurman, D., Colpaert, P., De Marez, L., 2014. Urban socio-technical innovations with and by citizens. *Interdisciplinary Studies Journal* 3, 143–156.
- Berkes, F., 2009. Evolution of co-management: Role of knowledge generation, bridging organizations and social learning. *J. Environ. Manag.* 90, 1692–1702.
- Berrang-Ford, L., Ford, J.D., Lesnikowski, A., Poutiainen, C., Barrera, M., Heymann, S.J., 2014. What drives national adaptation? A global assessment. *Clim. Chang.* 124, 441–450.
- Biesbroek, G.R., Dupuis, J., Jordan, A., Wellstead, A., Howlett, M., Cairney, P., Rayner, J., Davidson, D., 2015. Opening up the black box of adaptation decision-making. *Nat. Clim. Chang.* 5, 493–494.
- Birkmann, J., Garschagen, M., Setiadi, N., 2014. New challenges for adaptive urban governance in highly dynamic environments: Revisiting planning systems and tools for adaptive and strategic planning. *Urban Clim.* 7, 115–133.
- Bremer, S., Meisch, S., 2017. Co-production in climate change research: reviewing different perspectives. *Wiley Interdiscip. Rev. Clim. Chang.* 8.
- Briscoe, G., Mulligan, C., 2015. Digital Innovation: The Hackathon Phenomenon. Queen Mary University London, Queen Mary University London Research Online.
- Burch, S., 2010. Transforming barriers into enablers of action on climate change: Insights from three municipal case studies in British Columbia, Canada. *Glob. Environ. Chang.* 20, 287–297.
- Cashmore, M., Wejs, A., 2014. Constructing legitimacy for climate change planning: a study of local government in Denmark. *Glob. Environ. Chang.* 24, 203–212.
- Dannevig, H., Rauken, T., Hovelsrud, G., 2012. Implementing adaptation to climate change at the local level. *Local Environ.* 17, 597–611.
- Dannevig, H., Hovelsrud, G.K., Husabø, I.A., 2013. Driving the agenda for climate change adaptation in Norwegian municipalities. *Environment and Planning C: Government and Policy* 31, 490–505.
- Di Giulio, G.M., Torres, R.R., Lapola, D.M., Bedran-Martins, A.M., da Penha Vasconcellos, M., Braga, D.R., Fuck, M.P., Juk, Y., Nogueira, V., Penna, A.C., 2019. Bridging the gap between will and action on climate change adaptation in large cities in Brazil. *Reg. Environ. Chang.* 19, 2491–2502.
- Dilling, L., Pizzi, E., Berggren, J., Ravikumar, A., Andersson, K., 2017. Drivers of adaptation: responses to weather- and climate-related hazards in 60 local governments in the Inter-mountain Western US. *Environment and Planning A: Economy and Space* 49, 2628–2648.
- Duncombe, R., Cale, L., Harris, J., 2018. Strengthening 'the foundations' of the primary school curriculum. *Education* 3-13 (46), 76–88.
- Egebbø, H., 2019. Kollektiv kvalitativ analyse. *Norsk sosiologisk tidsskrift* 4, 106–122.
- Eisenack, K., Moser, S.C., Hoffmann, E., Klein, R.J., Oberlack, C., Pechan, A., Rotter, M., Termeer, C.J., 2014. Explaining and overcoming barriers to climate change adaptation. *Nat. Clim. Chang.* 4, 867–872.
- Ekstrom, J.A., Moser, S.C., 2014. Identifying and overcoming barriers in urban climate adaptation: case study findings from the San Francisco Bay Area, California, USA. *Urban Clim.* 9, 54–74.
- Funtowicz, S.O., Ravetz, J.R., 1993. The emergence of post-normal science, science. *Politics and Morality.* Springer 85–123.



- Haarstad, H., 2014. Climate change, environmental governance and the scale problem. *Geogr. Compass* 8, 87–97.
- Hampel, T., Heckmann, P., 2005. Deliberative handling of knowledge diversity—the pyramid discussion and position—commentary—response methods as specific views of collaborative virtual knowledge spaces, Society for Information Technology & teacher Education International Conference. Association for the Advancement of Computing in Education (AACE), Phoenix, AZ, USA 2005.
- Hewitt, C.D., Stone, R.C., Tait, A.B., 2017. Improving the use of climate information in decision-making. *Nat. Clim. Chang.* 7, 614.
- Jasanoff, S., 2010. A new climate for society. *Theory, Culture & Society* 27, 233–253.
- Jordan, R., 1990. Pyramid discussions. *ELT J.* 44, 46–54.
- Kolstad, E.W., Sofienlund, O.N., Kvamsås, H., Stiller-Reeve, M.A., Neby, S., Paasche, Ø., Pontoppidan, M., Sobolowski, S.P., Haarstad, H., Oseland, S.E., 2019. Trials, errors, and improvements in coproduction of climate services. *Bull. Am. Meteorol. Soc.* 100, 1419–1428.
- Kvamsås, H., Stiller-Reeve, M.A., 2018. Rapport 2018 Klimathon - Utfordringer og moglege løsninger for lokal klimatilpassing i Noreg. NORCE, Bergen Link to online report.
- Lara, M., Lockwood, K., 2016. Hackathons as community-based learning: a case study. *TechTrends* 60, 486–495.
- Lawrence, J., Sullivan, F., Lash, A., Ide, G., Cameron, C., McGlinchey, L., 2015. Adapting to changing climate risk by local government in New Zealand: institutional practice barriers and enablers. *Local Environ.* 20, 298–320.
- Lemos, M.C., 2015. Usable climate knowledge for adaptive and co-managed water governance. *Curr. Opin. Environ. Sustain.* 12, 48–52.
- Lemos, M.C., Morehouse, B.J., 2005. The co-production of science and policy in integrated climate assessments. *Glob. Environ. Chang.* 15, 57–68.
- Linnell, N., Figueira, S., Chintala, N., Falzarano, L., Ciancio, V., 2014. Hack for the homeless: a humanitarian technology hackathon, IEEE Global Humanitarian Technology Conference (GHTC 2014). IEEE 577–584.
- Lodge, M., Wegrich, K., 2014. *The Problem-Solving Capacity of the Modern State: Governance Challenges and Administrative Capacities*. Oxford University Press, USA.
- Moser, S.C., Ekstrom, J.A., 2010. A framework to diagnose barriers to climate change adaptation. *Proc. Natl. Acad. Sci.* 107, 22026–22031.
- Moser, S., Ekstrom, J., Kim, J., Heitsch, S., 2019. Adaptation finance archetypes: local governments' persistent challenges of funding adaptation to climate change and ways to overcome them. *Ecol. Soc.* 24.
- Neby, S., 2019. Climate adaptation and preparedness in Norway: third order effects, small-scale wickedness and governance capacity. *International Public Management Review* 19.
- Neby, S., 2020. Klimathon II 2019 Om samproduksjonsmetodikk, utfordringer og løsninger for lokal klimatilpassing. NORCE, Bergen Link to online report.
- Oberlack, C., 2017. Diagnosing institutional barriers and opportunities for adaptation to climate change. *Mitig. Adapt. Strateg. Glob. Chang.* 22, 805–838.
- O'Brien, K., 2017. *Climate Change Adaptation and Social Transformation*. People, the Earth, Environment and Technology. American Association of Geographers, Wiley Online Library, International Encyclopedia of Geography, pp. 1–8.
- O'Brien, K., Sygna, L., Haugen, J.E., 2004. Vulnerable or resilient? A multi-scale assessment of climate impacts and vulnerability in Norway. *Clim. Chang.* 64, 193–225.
- Orderud, G., Naustdalslid, J., 2020. Climate change adaptation in Norway: learning-knowledge processes and the demand for transformative adaptation. *International Journal of Sustainable Development & World Ecology* 27, 15–27.
- Ostrom, E., 1996. Crossing the great divide: coproduction, synergy, and development. *World Dev.* 24, 1073–1087.
- Patterson, J., de Voogt, D.L., Sapiains, R., 2019. Beyond inputs and outputs: Process-oriented explanation of institutional change in climate adaptation governance. *Environ. Policy Gov.* 29, 360–375.
- Pogačar, K., Žižek, A., 2016. Urban hackathon—alternative information based and participatory approach to urban development. *Procedia Engineering* 161, 1971–1976.
- Reckien, D., Flacke, J., Olazabal, M., Heidrich, O., 2015. The influence of drivers and barriers on urban adaptation and mitigation plans—an empirical analysis of European cities. *PLoS One* 10.
- Simonet, G., Leseur, A., 2019. Barriers and drivers to adaptation to climate change—a field study of ten French local authorities. *Clim. Chang.* 155, 621–637.
- Termeer, C., Dewulf, A., Breeman, G., 2013. Governance of wicked climate adaptation problems, climate change governance. Springer, 27–39.
- Trainer, E.H., Kalyanasundaram, A., Chaihirunkarn, C., Herbsleb, J.D., 2016. How to Hackathon: Socio-Technical Tradeoffs in Brief, Intensive Collocation, Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing, 1118–1130.
- Uittenbroek, C.J., Janssen-Jansen, L.B., Runhaar, H.A., 2013. Mainstreaming climate adaptation into urban planning: overcoming barriers, seizing opportunities and evaluating the results in two Dutch case studies. *Reg. Environ. Chang.* 13, 399–411.
- Vink, M.J., Dewulf, A., Termeer, C., 2013. The role of knowledge and power in climate change adaptation governance: a systematic literature review. *Ecol. Soc.* 18.
- Wall, T.U., Meadow, A.M., Horganic, A., 2017. Developing evaluation indicators to improve the process of coproducing usable climate science. *Weather, Climate, and Society* 9, 95–107.
- Wamsler, C., 2017. Stakeholder involvement in strategic adaptation planning: Transdisciplinarity and co-production at stake? *Environ. Sci. Pol.* 75, 148–157.
- Westskog, H., Hovelsrud, G.K., Sundqvist, G., 2017. How to make local context matter in national advice: Towards adaptive comanagement in Norwegian climate adaptation. *Weather, Climate, and Society* 9, 267–283.